University of Victoria | Graduate Studies

Notice of the Final Oral Examination
for the Degree of Doctor of Philosophy

of

MICHÈLE DE LA CHEVROTIÈRE

MSc (University of Victoria, 2008)
BSc (Université de Montréal, 2002)

"Stochastic and Numerical Models for Tropical Convection and Hadley-Monsoon Dynamics"

Department of Mathematics and Statistics

Tuesday, August 18, 2015
1:00PM
David Turpin Building
Room A144

Supervisory Committee:
Dr. Boualem Khouider, Department of Mathematics & Statistics, University of Victoria (Supervisor)
Dr. Reinhard Illner, Department of Mathematics & Statistics, UVic (Member)
Dr. Julie Zhou, Department of Mathematics & Statistics, UVic (Member)
Dr. Norm McFarlane, School of Earth & Ocean Sciences, UVic (Outside Member)

External Examiner:
Dr. Philip Austin, Earth, Ocean & Atmospheric Sciences, University of British Columbia

Chair of Oral Examination:
Dr. David Harrington, Department of Chemistry, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

The poor representation of cloud processes in general circulation models (GMCs) has been recognized for decades as one of the major sources of uncertainties in weather and climate predictions. Because of the coarse spatial resolution of GCMs, subgrid-scale cloud and convection processes are modelled by parameterization schemes that provide a statistical representation of the subgrid-scale processes in terms of the largescale, gridbox fields. This thesis focuses on the stochastic multicloud parameterization of Khouider et al. (2010), which is based on the three cloud types (congestus, deep, and stratiform) that are most observed in tropical convective systems. A rigorous parameter estimation model based on the Bayesian paradigm is developed to infer from data a set of seven convective timescales that determine the transition rates from one cloud type to another in the multicloud framework. The Bayesian posterior is given in terms of a costly model likelihood function that must be approximated numerically using high-performance linear algebra routines for parallel distributed computing. The Bayesian procedure is applied to the Giga-LES dataset of Khairoutdinov et al. (2009), a large-eddy simulation of tropical deep convection that covers a physical domain comparable to that of a typical horizontal grid cell in a GCM. The stochastic multicloud model and its deterministic version are then coupled to a zonally symmetric atmospheric model to study the meridional Hadley circulation and monsoon dynamics. The main model is based on the hydrostatic Boussinesq equations on a rotating sphere, and is composed of a deep convective troposphere and a dynamical planetary boundary layer to sustain shallow convection. The resulting equations form a system of nonconservative partial different equations, which is solved numerically using high order non-oscillatory finite volume methods. Results from deterministic and stochastic simulations reveal a mean local Hadley cell structure with some features of organized convection. In the stochastic case, the Giga-LES parameter regime best captures the Hadley-type circulation and monsoon trough features, compared to a parameter regime obtained used in a different study.